Automated Text Simplification as a reading aid for low-vision individuals

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RÉSEAU DE RECHERCHE EN SANTÉ DE LA VISION
VISION HEALTH RESEARCH NETWORK

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Automated Text Simplification as a reading aid for low-vision individuals

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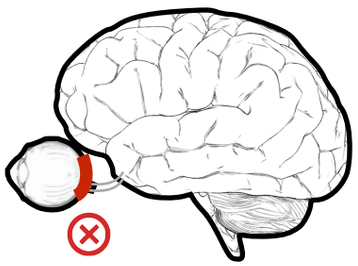
Inria inventeurs du monde numérique

Equipe Projet Biovision
Inria Sophia-Antipolis Méditerranée

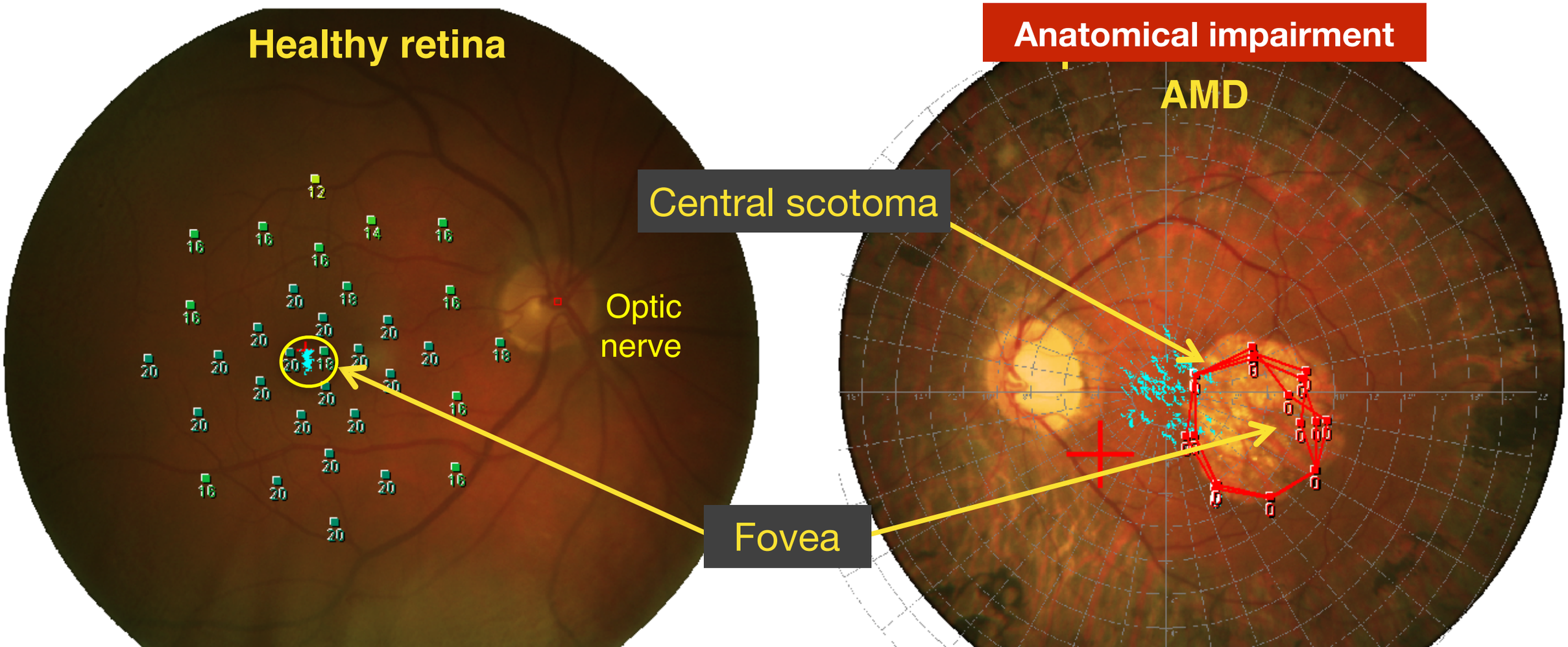
Background

Central Field Loss (CFL)



Maculopathies

- **Age-related Macular Degeneration (AMD)** → **1st cause of visual impairment > 50 years old**
- Diabetic retinopathy
- Myopic retinopathy
- Cone dystrophy
- Stargardt's disease



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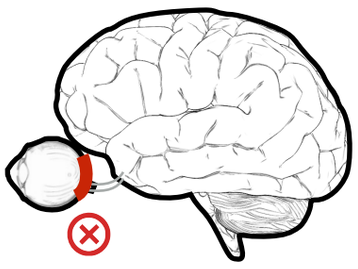

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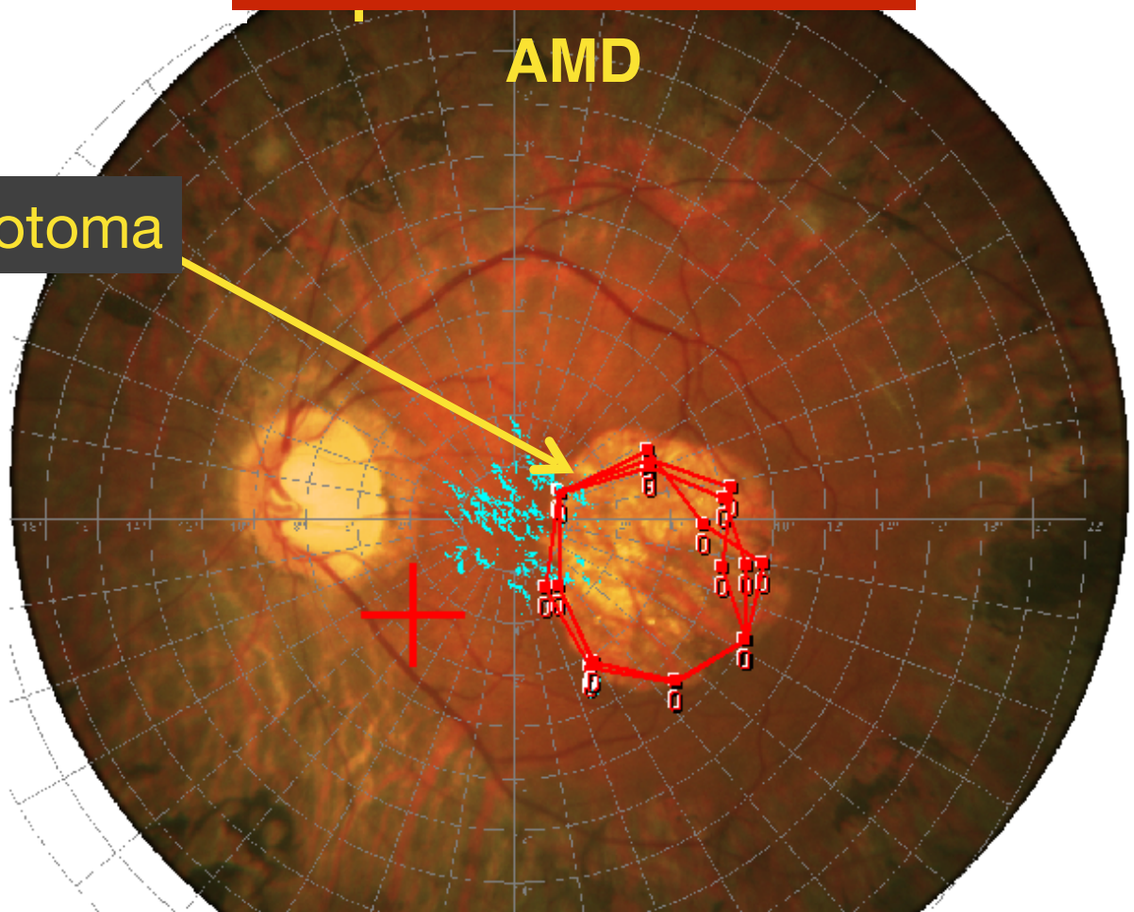
Functional impairment

Visual field

Central scotoma

Anatomical impairment



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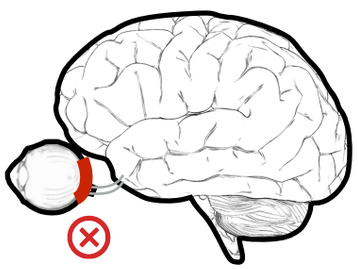

Maculopathies

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Functional impairment

Visual field

Reading

Eccentric vision

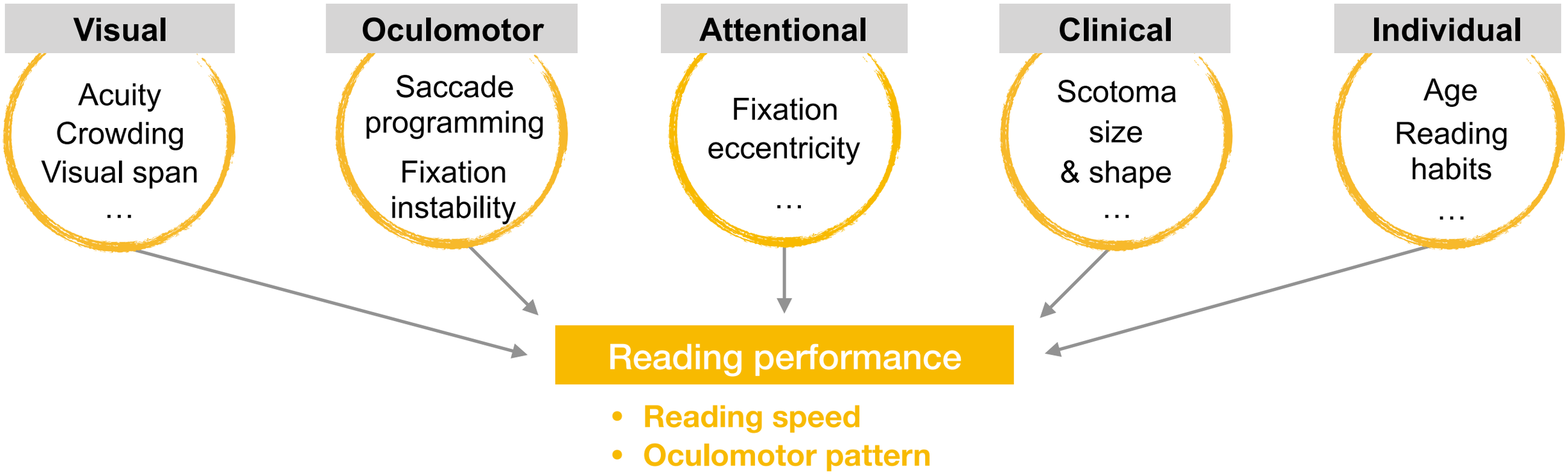
Motivation

Understanding the processes of reading with eccentric vision

Personalised rehabilitation protocols

Personalised visual aids

What are the underlying factors of poor reading performance with central field loss?



Outline

STUDY 1

STUDY 2

STUDY 3

Outline

Eye movement pattern when reading with CFL

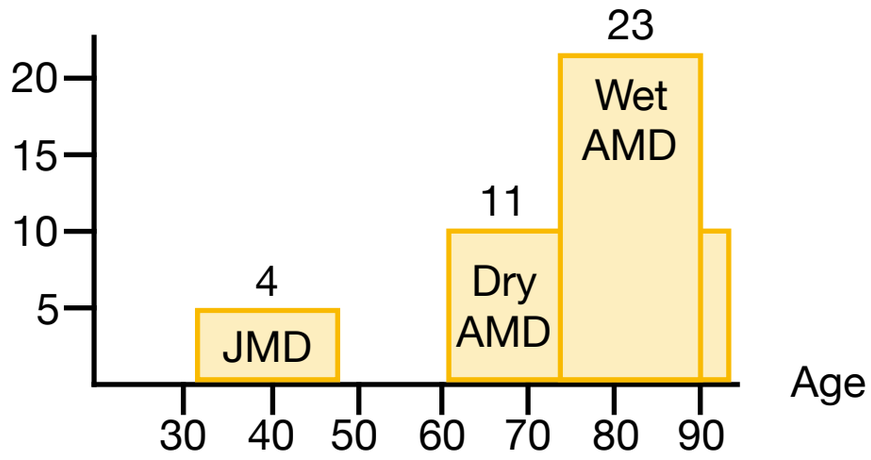
STUDY 1

Calabrèse, A., Bernard, J.-B., Faure, G., Hoffart, L., & Castet, E. (2016). Clustering of Eye Fixations: A New Oculomotor Determinant of Reading Speed in Maculopathy. *Investigative Ophthalmology & Visual Science*, 57(7), 3192-3202.

STUDY 1 Eye movement pattern when reading with CFL

Methods

- **38 patients** with binocular CFL

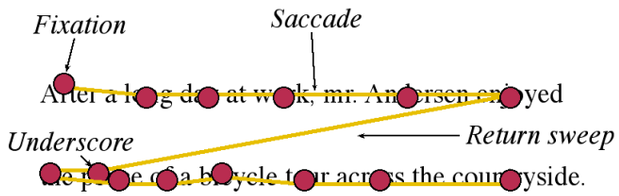


- Acuity from 20/250 to 20/63 (better eye)
- Only **absolute binocular scotoma**

Stimuli

"You open my door"

Eye-tracking



Eye fixation positions

Reading speed *(whole sentence)*

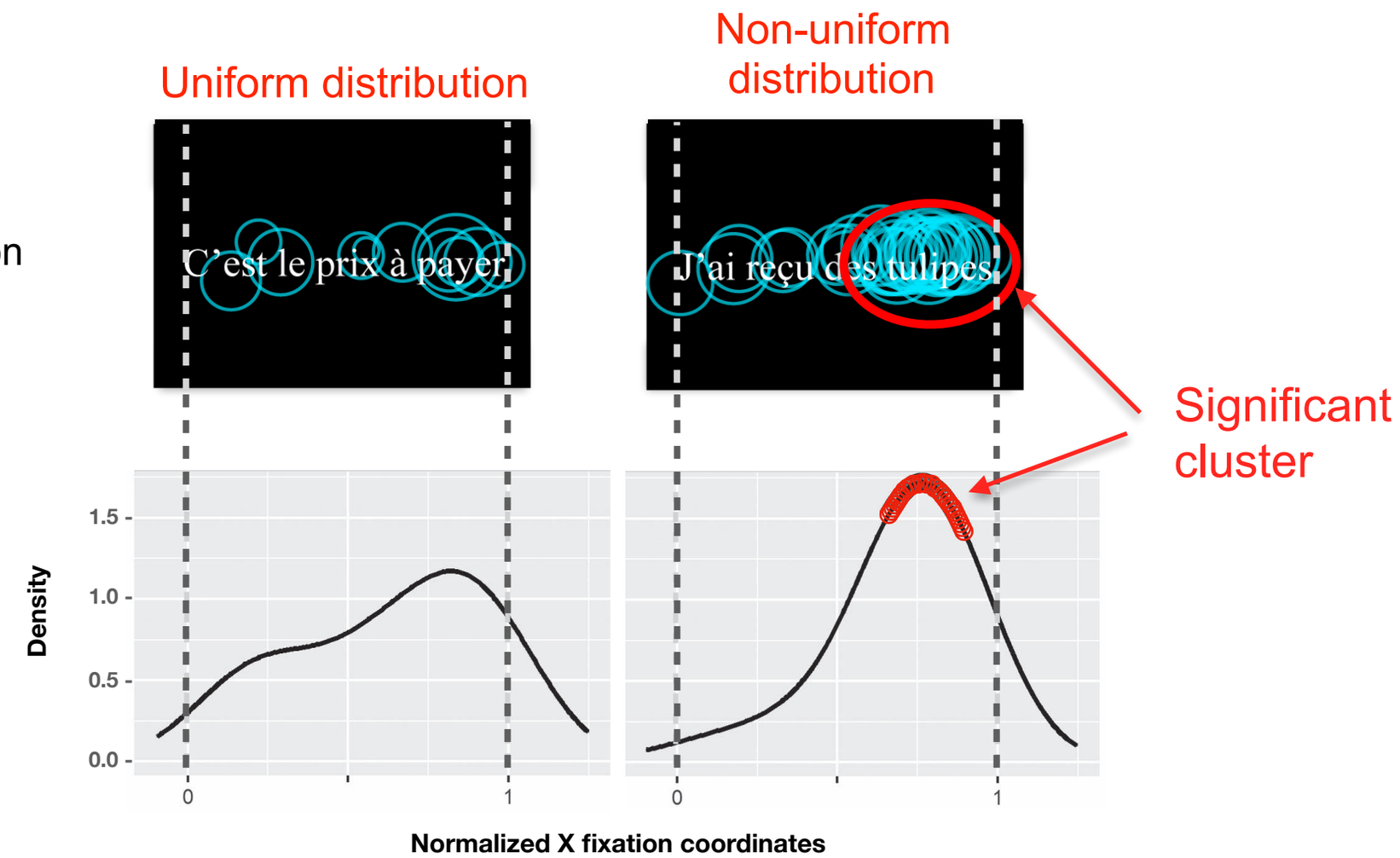
Calabrèse et al., 2016 - *IOVS*

STUDY 1 Eye movement pattern when reading with CFL

Results

1- We defined a new oculomotor factor: the non-uniformity of fixations

= 1 fixation



2 very different distributions of fixations for the same patient

Calabrèse et al., 2016 - *IOVS*

STUDY 1 Eye movement pattern when reading with CFL

Results

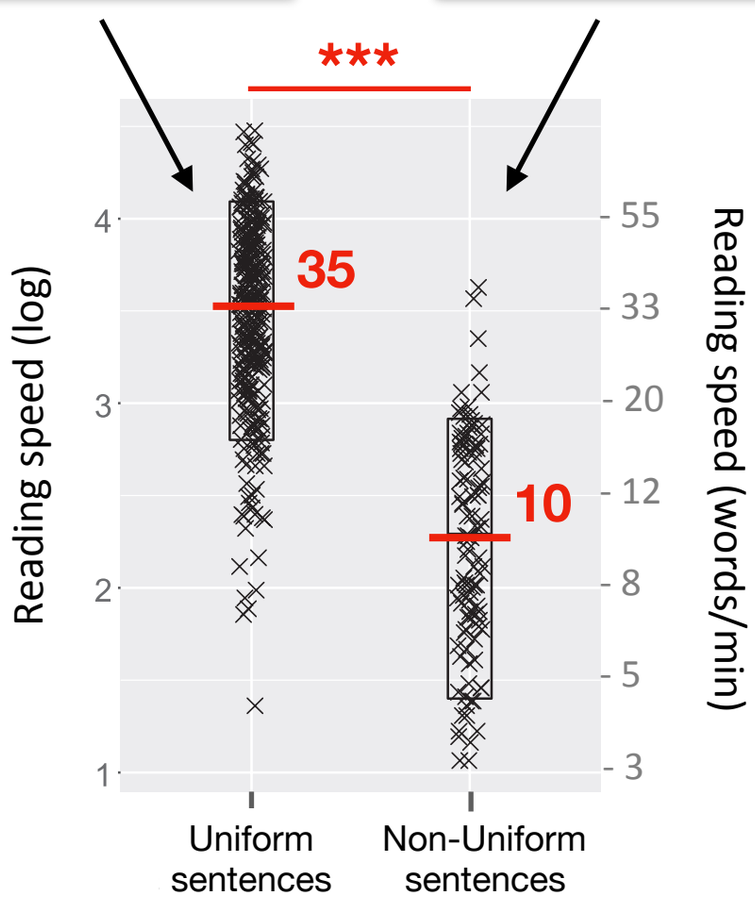
1- We defined a new oculomotor factor: the non-uniformity of fixations

2- We measured the effect of this new factor on reading speed

= 1 fixation

Uniform distribution

Non-uniform distribution



Reading speed is significantly reduced when the pattern of fixations is non-uniform *(p < 0.0001)*

Calabrèse et al., 2016 - *IOVS*

Eye movement pattern when reading with CFL

Results

1- We defined a new oculomotor factor: the non-uniformity of fixations
2- We measured the effect of this new factor on reading speed
3- We investigated factors that could explain the non-uniformity

Patient specific factors:

- Fixation instability → *no effect*
- Scotoma size → *no effect*
- Visual acuity → *no effect*
- Pathology → *no effect*
- Age → *no effect*

Sentence specific factors:

- Word frequency → *significant effect*

The probability to find a fixation cluster within a sentence increases when the frequency of the lowest-frequency word decreases

STUDY 1 Eye movement pattern when reading with CFL

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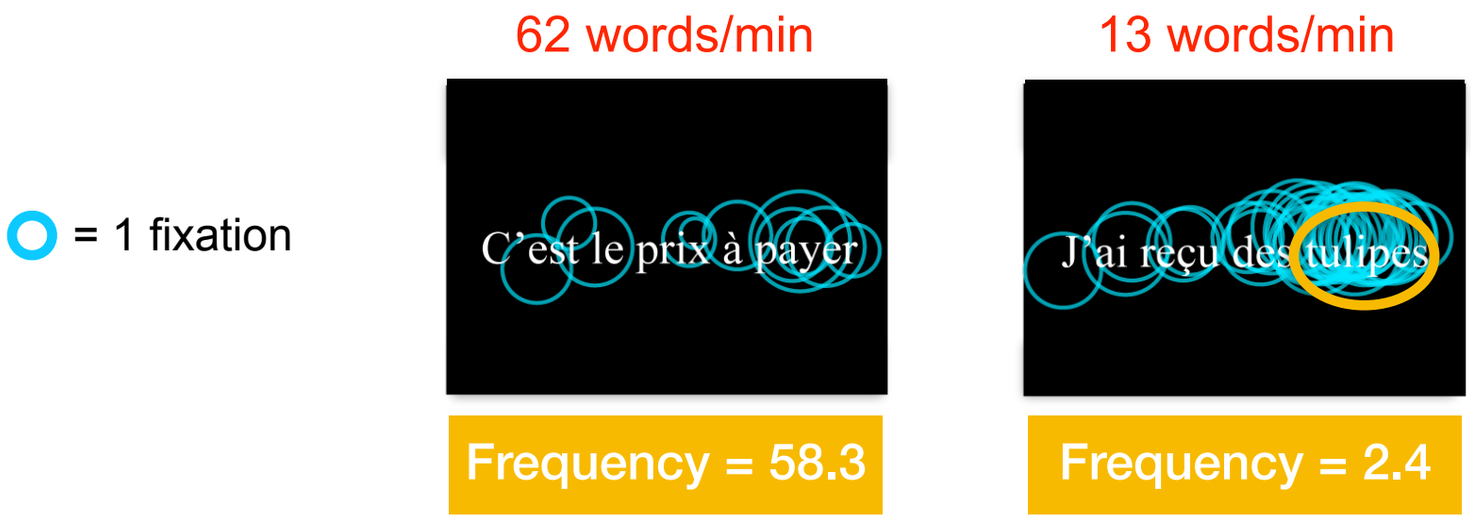


Sentence specific factors:

- Word frequency → *significant effect*

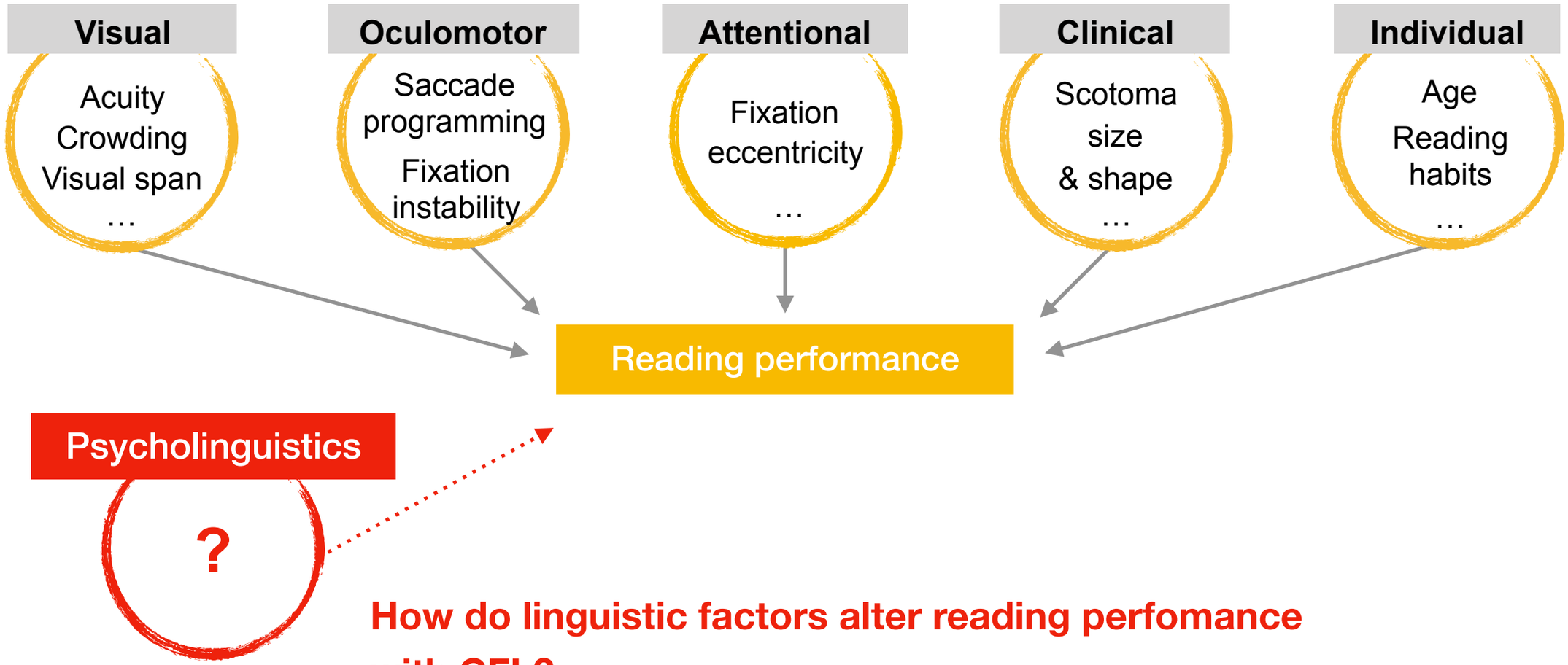
The probability to find a fixation cluster within a sentence increases when the frequency of the lowest-frequency word decreases

Calabrèse et al., 2016 - *IOVS*

Eye movement pattern when reading with CFL

Conclusions

Underlying factors of poor reading performance with central field loss…



How do linguistic factors alter reading perfomance with CFL?

Could we modify the text itself to make it more accessible to CFL?

Calabrèse et al., 2016 - *IOVS*

Outline

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Effect of word frequency when reading with CFL

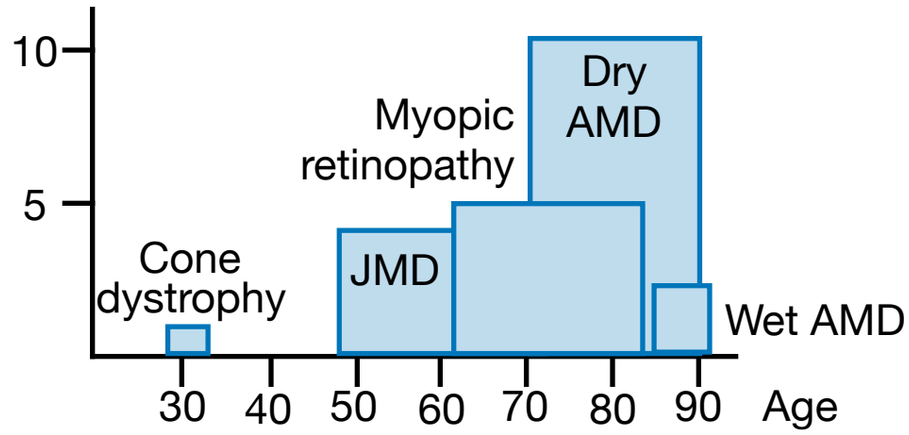
STUDY 2

Stolowy, N.*, Calabrèse, A.*, Sauvan, L., Aguilar, C., François, T., Gala, N., et al. (2019) The Influence of Word Frequency on Word Reading Speed when Individuals with Macular Diseases Read Text. *Vision Research,* 155, 1-10 **joint first authors*

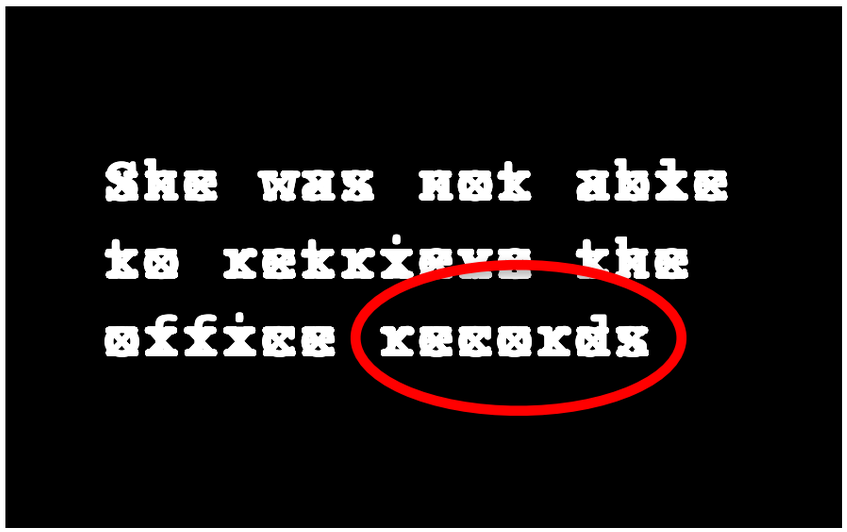
STUDY 2 Effect of word frequency when reading with CFL

Methods - *participants*

- **23 patients** with binocular CFL
- Acuity from 20/400 to 20/63 (better eye)
- Only **absolute binocular scotoma**



Methods - *reading paradigm*



Self-paced reading

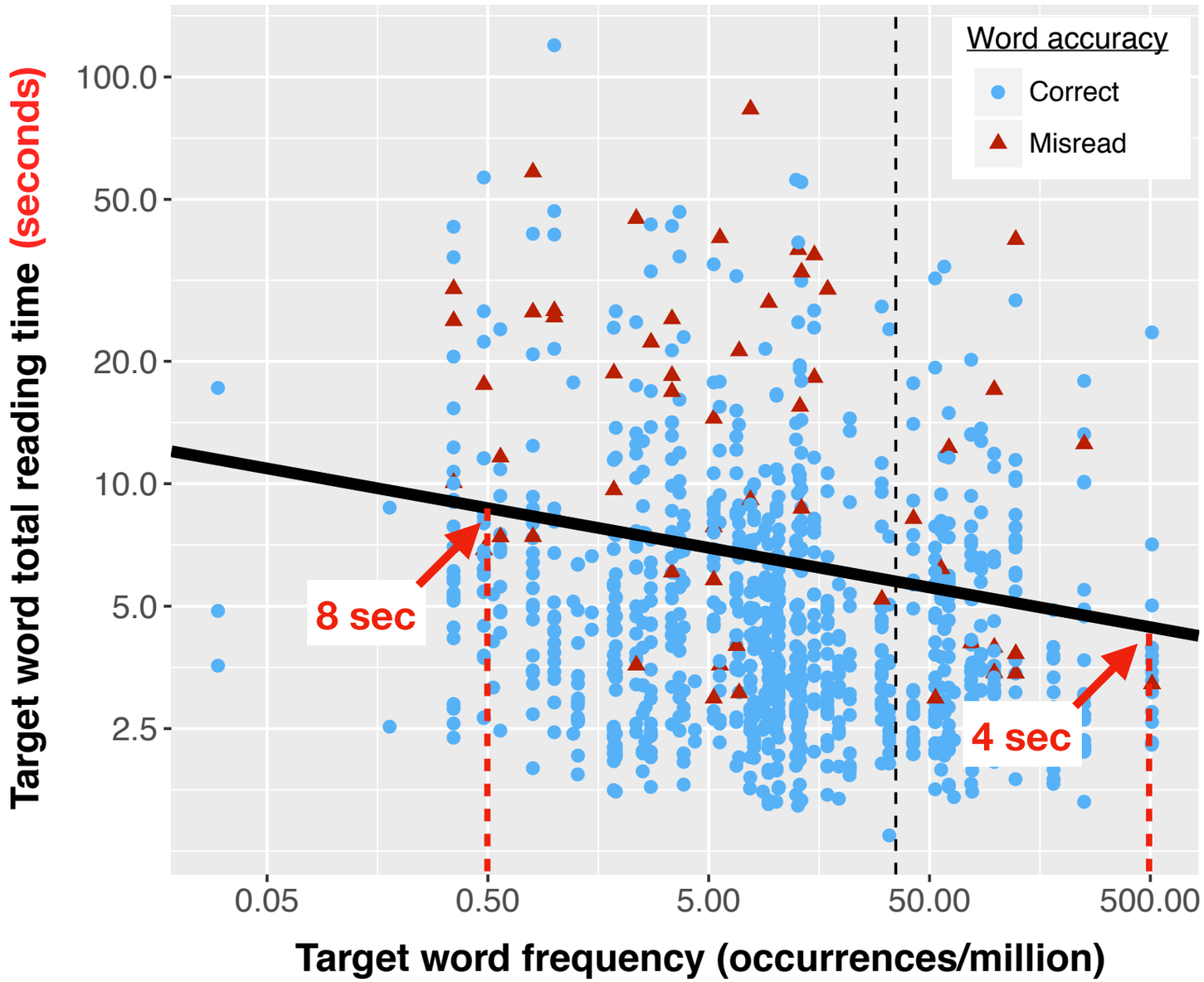
→ Reading time *(individual words)*

Eye-tracking

Stolowy et al., 2019 - *Vision Research*

STUDY 2 Effect of word frequency when reading with CFL

Results



Reading time decrease

=

Reading speed increase

Facilitator effect of frequency

Multiplying frequency by 1000 decreases reading time by 50%

Stolowy et al., 2019 - *Vision Research*

Outline

Eye movement pattern when reading with CFL

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Effect of word neighborhood size when reading with CFL

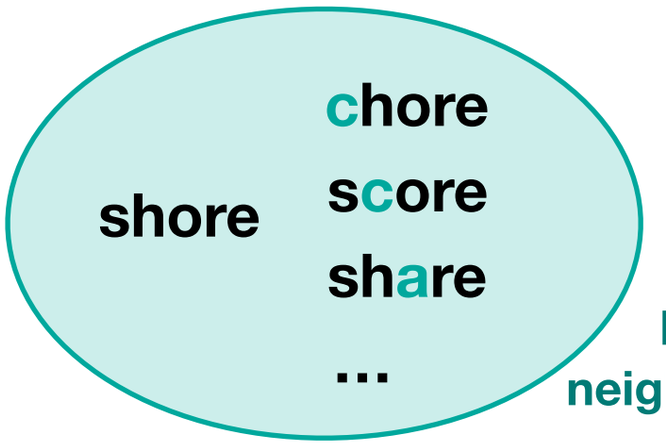
STUDY 3

Sauvan, L., Stolowy, N., Aguilar, C., François, T., Gala, N., Matonti, F., et al. (2020) The inhibitory effect of word neighborhood size when reading with central field loss is modulated by word predictability and reading proficiency. *Scientific Reports, 10, 21792*.

STUDY 3 Effect of word neighborhood size when reading with CFL

Word neighborhood size - *definition*

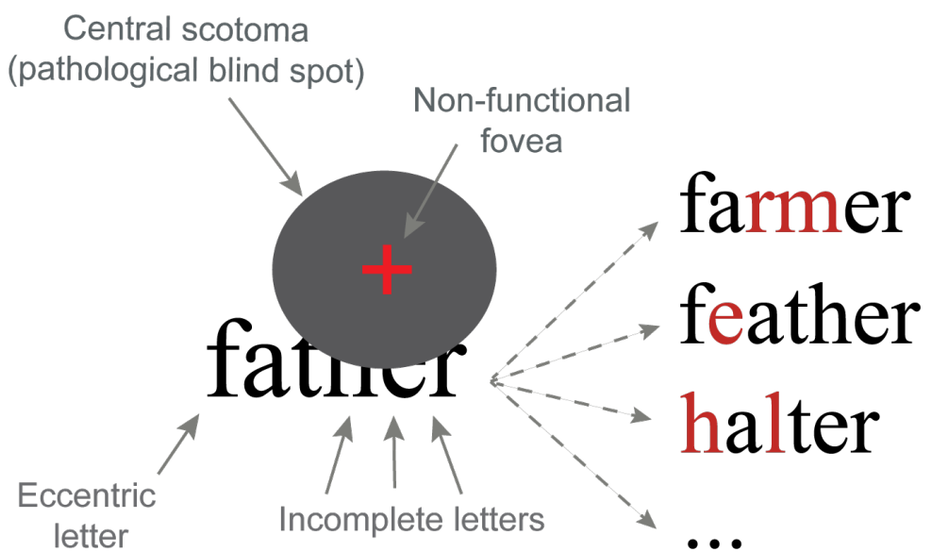
N = Number of words that can be formed from a single word by changing only one letter



neighbor ✗

Large neighborhood size → **Facilitator effect with normal vision**

Hypotheses



Hyp. 1

Negative effect on reading speed

Hyp. 2

The more predictable a word is the smaller the effect

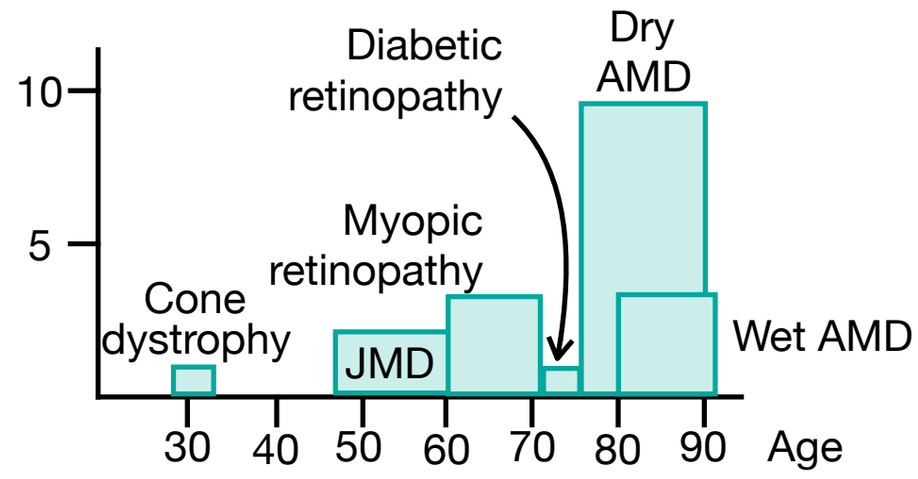
Hyp. 3

The interaction depends on reading proficiency

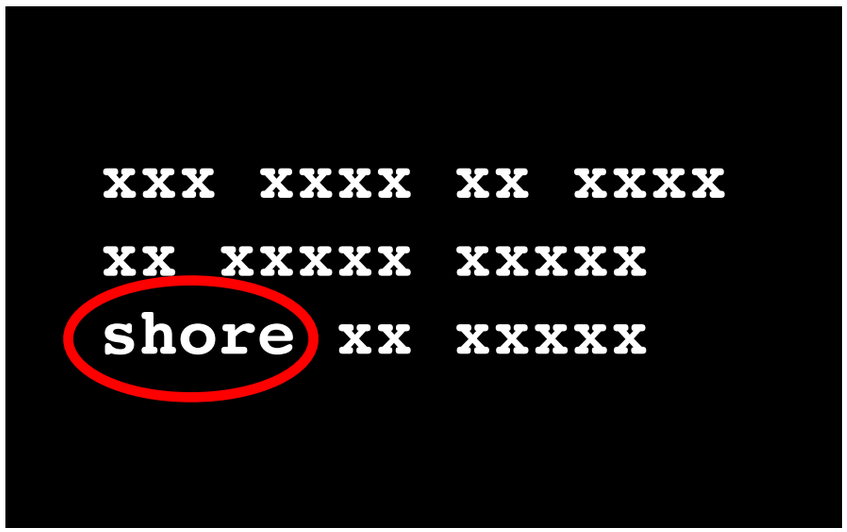
STUDY 3 Effect of word neighborhood size when reading with CFL

Methods - *participants*

- **19 patients** with binocular CFL
- Acuity from 20/400 to 20/50 (better eye)
- Only **absolute binocular scotoma**



Methods - *reading paradigm*



Self-paced reading

Reading time *(individual words)*

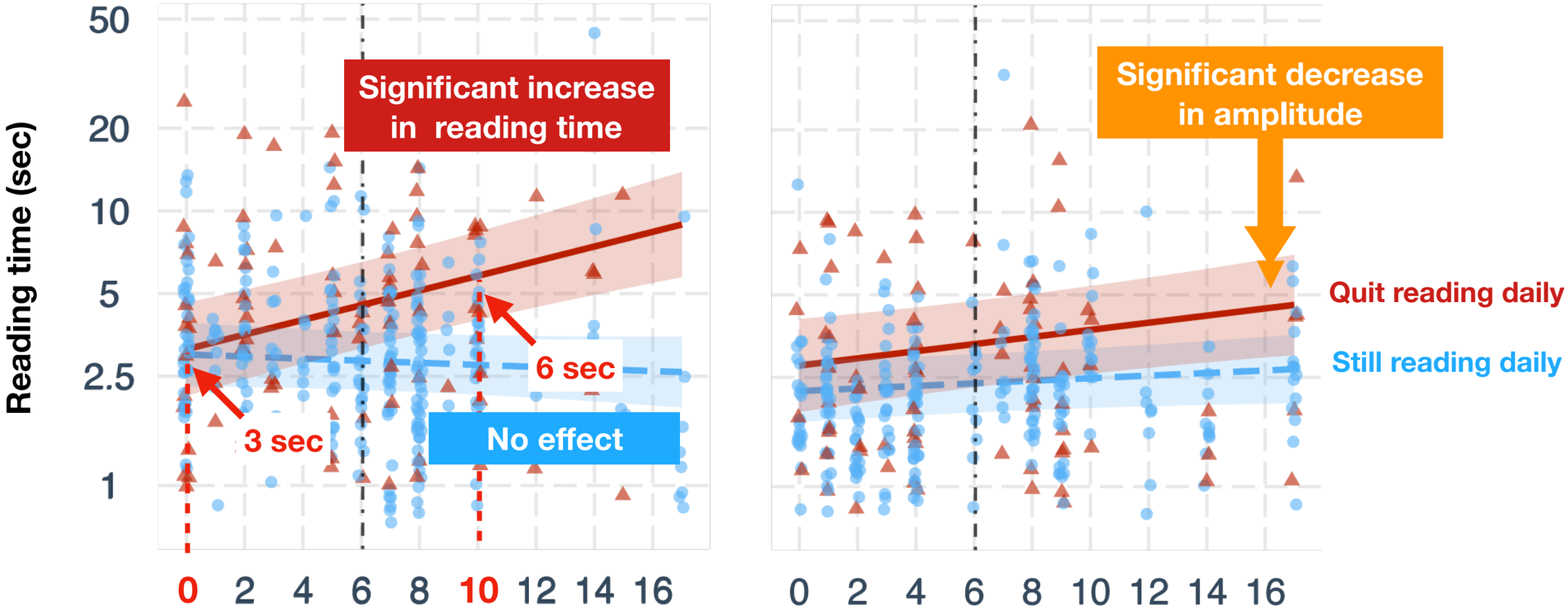
Eye-tracking

Sauvan et al., 2020 - *Scientific Reports*

STUDY 3 Effect of word neighborhood size when reading with CFL

Results

Predictability ⊖ ⊕⊕



Hyp. 1
Negative effect on reading speed ✓

Hyp. 2
The more predictable a word is the smaller the effect ✓

Hyp. 3
The interaction depends on reading proficiency ✓

Conclusions

★ **The linguistic properties of a text do influence reading performance differently in the presence of CFL.**

Psycholinguistic properties of a text must be investigated in the context of low vision *(e.g., lexical, syntactic, discursive).*

★ **Reading habits and proficiency seem to reduce text complexity in the presence of CFL.**

Reinforce the need to provide patients with individualised rehabilitative care of functional vision to help maintain daily reading practice.

★ **Text simplification should be considered as a potential rehabilitation tool and daily reading assistive technology.**

Automated text simplification software could be developed in the form of tablet apps or web browser.

By increasing reading accessibility, it would foster overall reading ability and fluency through increased practice.

Happy faces!

Fondation de France

N. Gala

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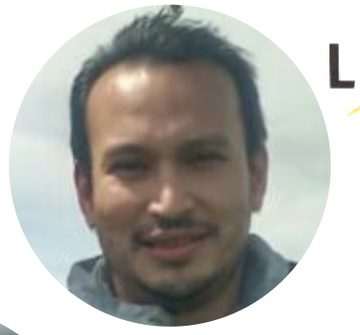
PAROLE ET LANGAGE

E. Castet

cnrs

C. Aguilar



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L. Sauvan

AP HM
Assistance Publique
Hôpitaux de Marseille

AMD/Low Vision
Awareness
Month

• February •

Thank you